

Concrete Floor Finishes



A DURABLE FLOOR FOR SEVERE SERVICE

An excellent example of a heavy duty concrete floor finish installed in the Woodward and Tiernan Printing Company plant, St. Louis, in 1926. The surface was ground with terrazzo machines, producing a serviceable floor, to facilitate heavily loaded truck movement with minimum expenditure of power.



CONCRETE FLOOR IN CONCOURSE, CHICAGO AND NORTHWESTERN RAILWAY TERMINAL, CHICAGO

After twenty years of the most severe service, this concrete floor installed in 1908 is in perfect condition. The durability of this wearing surface reflects the care exercised in its placing, finishing and curing. Frost & Granger, Chicago, Architects.

CONCRETE FLOOR FINISH

THE advantages inherent in properly made concrete floor finishes are many. They are durable, serviceable and economical. Concrete floors are as nearly permanent as any that can be produced. Maintenance and depreciation, which add to the cost of less durable types of finish, are reduced to a minimum when high-grade concrete wearing surfaces are involved. For cleanliness such floors are unquestionably superior because of their density, low absorption and freedom from open joints which collect dirt and make cleaning difficult. Smoothness and rock hardness make them ideally suited for areas subjected to heavy trucking. Wetting does not damage them. The fire resistance of concrete floor finishes is an important advantage.

The construction of floors and floor finishes is of equal or greater importance than the construction of any other portion of a building. Besides being required to resist dead load through its inherent strength, a floor must take the full force of pounding and abrasive live loads. These facts should be constantly borne in mind by the owner, architect and contractor from the time the building is first planned until the final construction is completed and the floor is finished, cured and turned over to the owner. Negligence at one stage may defeat best practices at any other.

REQUIREMENTS FOR DURABLE CONCRETE

The subject matter of this booklet deals with the wearing course or top finish of concrete floors. The structural slab which carries the surface is discussed only to the extent of showing its relation to the topping. The base slab is usually constructed in the same manner as the other structural members of a building, but the comparatively thin wearing course for the finish involves different manipulation. Through variations in the kind, quantity and proportion of materials, including water, concrete floor finishes of widely different characteristics can be made. The purpose of this publication is to point out the factors controlling the achievement of durable concrete floor finishes that will serve the purpose for which they are designed.

The basic principles of making concrete are the same regardless of the type of structure involved. For this reason many of the same factors enter into the making of concrete whether it is to be used for the structural members of a building, the base for a floor, or for the floor topping. There will be found in the succeeding paragraphs a discussion of the material "Concrete," with particular reference to its successful use for wearing surfaces of floors. Typical specifications are also given for the several types of finishes.

Fundamentals of Concrete

Concrete is one of the most durable materials for floor use. When concrete floors are constructed for durability, sufficient strength will also be provided.

The major factors affecting the durability of concrete, particularly in floor finishes, are (1) the nature of the aggregates, and (2) the water-tightness of the concrete.

Nature of the Aggregates

Aggregates form nearly three-quarters of the mass of hardened concrete, and therefore are an important consideration in the production of durable floors. In certain classes of heavy duty floor finishes, aggregates perform a function that is not often necessary in other concrete structures. Aggregates in the wearing course are exposed by grinding so that they will take the abrasion and wear incident to trucking or other duty imposed on the floor. For this reason, aggregates of sufficient toughness and hardness should be carefully selected. Trap rock of a dense, fine grained and inter-locking crystalline structure is an excellent type of aggregate for severe service. Hard, fine grained granites and quartzites are also suitable. For floors of a decorative nature, or where the duty imposed is not severe, aggregates of less hardness may be selected.

In all cases aggregates should be crushed in a manner that will provide particles of regular structure conducive to good anchorage. Elongated or thin plate-like fragments should never be used.

All aggregates should be clean, free from dust or highly weathered fragments and should consist of particles which will not alter in physical or chemical nature in the presence of moisture. New and untried aggregates should be subjected to study before they



FIVE YEARS OF TRUCKING HEAVY LOADS HAS NOT MARRED THIS CONCRETE FLOOR FINISH

Crushed trap rock aggregate was used in this wearing course and the surface was finished by troweling. The hard wearing quality of this floor is largely due to the control of the water-cement ratio in mixing and adequate curing. This floor is at the plant of the Columbia Can Company, St. Louis, Missouri.



REMOVING EXCESS WATER BY THE USE OF AN ABSORBENT COVERING

Immediately after striking off, the wearing course is covered with dampened burlap and a mixture of dry cement and sand. This absorbs some of the free water in the mix, and in effect reduces the water-cement ratio of the topping. After removal of the absorbent, the finish is compacted by an electrically operated disc float, and then troweled by hand.

are used in finishes intended for long service under severe conditions of wear.

Grading of Aggregates

The grading or granular composition of the aggregates is equally as important as their hardness, shape and other characteristics. The fine aggregate or sand should consist chiefly of coarser grains ranging from $\frac{1}{16}$ to $\frac{1}{4}$ inch in size. Not more than 5 per cent of the grains should pass a 100 mesh sieve, and not more than 10 per cent should pass a 50 mesh sieve. Sand consisting only of very fine particles should not be used. Stone-dust, clay and silt are particularly objectionable. Coarse aggregate should be well graded pea gravel or crushed stone, particles ranging between $\frac{1}{4}$ and $\frac{3}{8}$ inch in size; in other words, all coarse aggregate should pass a $\frac{1}{2}$ -inch sieve.

Metallic Aggregates

Metallic aggregates have been used successfully in the wearing surface of concrete floors. In selecting this material particular attention should be directed to proper grading, freedom from oil, grease, non-ferrous metals and other harmful impurities. It should not be water repellent. The directions of reliable manufacturers should be followed when this material is used, and the work should be entrusted to experienced contractors who have proved their ability to produce the type of finish required.

Water-tightness of Concrete

The importance of water-tightness in a concrete floor finish is not reflected alone in the ability of the finish to defeat the passage of water. Water-tightness also establishes the durability of the concrete and its ability to resist the action of any liquid or other substances that may come in contact with the floor. The greater portion of the wear on a floor is taken by the aggregates. There remains the attainment of sufficient strength in the binding medium (cement and water paste) to hold the aggregates firmly in place. This binding medium must also be water-tight. The requirements of water-tight concrete are impervious aggregates thoroughly incorporated in a cement-water paste, which is itself impervious. If this requirement is met, the paste will have sufficient strength.

The simple conception of the cementing medium of concrete as a paste will assist in giving a clearer idea of how to attain water-tightness. This medium consists of cement combined with water which will transform into a new substance by the chemical reaction of the two materials. It is through this cementing medium that properties of concrete are controlled.

The quality of the cement paste, and consequently the properties of concrete, will be affected by the relative proportions of the cement and mixing water. Water not used in the chemical process of hydration and which does not enter into combination with the

cement remains within the paste or mass, and the space it occupies will later be represented by air voids as the water evaporates. The larger these voids, the more channels there will be for the passage of liquids which may eventually be brought in contact with the concrete. Therefore the least amount of mixing water that will produce a workable mix must be used.

The Water-Cement Ratio

To obtain the desired workability, there must be sufficient paste to actually surround each aggregate particle. If the paste is thin or watery, segregation will take place and much of the excess water will collect at the top, forming laitance and giving a non-homogeneous mass which will have little resistance to the penetration of liquids or to wear. Thus the water-cement ratio is a major influence on the watertightness of the concrete floor finish in two important respects. First, through its influence on the imperviousness of the paste and, second, through its influence on the workability of the concrete.

With the water-cement ratio method of control, the proportion of the water to cement is fixed by specifications and workability is controlled by adjustments in the quantities of aggregates.

The use of excess mixing water not only lowers the quality of the concrete but makes troweling difficult unless the operation is delayed until some of the water has evaporated. Excessively wet concrete cannot be

troweled without bringing to the finished surface the fine material of the mixture which leaves a finish incapable of withstanding abrasion and wear.

Under certain well-controlled methods, it is possible to withdraw from the freshly placed concrete some of the excess water used in mixing. Any system or method of constructing concrete floor finishes that will effectively do this is worthy of consideration. Such processes should not be used to dispense with limiting the amount of mixing water nor to avoid careful design and adequate control of mixing, placing and finishing concrete floor finishes. One of the patented methods that has given satisfaction involves covering the plastic and unhardened concrete with dampened burlap, over which is spread a thin layer of dry cement and sand carefully proportioned in a 1 to 1 mix. This mixture acts as an absorbent and withdraws from the concrete some of its excess mixing water. After a limited time the burlap is removed, and the cement sand mixture is immediately sent to the mixer for use in subsequent batches of concrete. Floating and finishing of the wearing course is started as soon as the burlap covering is removed.

This method when carefully employed has the effect of reducing the water-cement ratio of the concrete wearing course, with the resulting advantages previously discussed. The system involves careful supervision and the use of well-trained labor, and should be assigned to a contractor capable of producing the finish desired.



APPLYING CONCRETE FLOOR FINISH TO HARDENED CONCRETE BASE OF SHIPPING PLATFORM

All stages of installing a finish course by a patented system are illustrated in this picture taken in the Montgomery Ward & Company building, Oakland, California. Starting at the extreme far end, the topping is being placed, then screeded, covered with an absorbent to remove excess water, and finally mechanically floated. The finishers in the foreground are giving the wearing course its final troweling.

The Importance of Curing

The remaining element which controls the character of concrete as reflected in the quality of the paste is the extent to which chemical reactions are allowed to progress. The continuation of these reactions in portland cement requires favorable curing conditions, that is, moderate temperature and the presence of moisture. It is through curing that the internal structure of the concrete is built up to provide strength and water-tightness.

As concrete hardens, water continues to enter into combination with the cement; therefore, it is necessary to keep the surface of the hardening concrete moist. The longer this curing period can be extended, the harder and stronger will be the concrete. It is usually recommended that the curing be continued over a period of a week to ten days, but even longer curing will be found profitable in improving the desirable qualities of the concrete.

It is frequently stated that the mixing water used in a concrete floor finish is sufficient to effect curing. This is true if the water can be retained, but with adverse conditions of relative humidity, temperature, and velocity of air currents immediately above or below the floor the excess water in the concrete will soon evaporate. To offset this drying out, water for curing should be applied to the floor surface as soon as the concrete is hard enough not to be marred by the process.

Neglect in curing a concrete floor finish is a more serious matter than is ordinarily appreciated. Because

of the small mass of the concrete involved and the relatively large area, special care must be taken to prevent floor finishes from drying out. When the drying action is delayed until after a proper curing period the surface is hard, dense and strong. On the other hand, rapid drying before these qualities have been acquired may result in checking and dusting.

Supervision of Construction

The price of success in producing a durable concrete floor finish is adequate and competent supervision. Frequently experienced labor, however specialized, becomes so accustomed to oft repeated work that it is performed mechanically. Thus, floor finishes are sometimes made with too much mixing water or placed in an unworkable condition, or not properly cured.

The inspector on floor work should have practical experience in the design and control of concrete mixtures as well as an understanding of the fundamental principles involved in the construction to which he is assigned.

In the design and control of concrete mixtures for floor finishes, careful inspection should be enforced in all of the operations relating to:

- (1) The selection of the materials, especially aggregates.
- (2) The design of the mixture.
- (3) Mixing, transporting and placing.
- (4) Protection and curing.

By careful and intelligent control in all of these stages, enduring concrete floor finishes can be achieved.



SCREEDING PLASTIC CONCRETE FLOOR FINISH ACCURATELY TO GRADE

Notice complete absence of water at the surface. Consistency of the topping is such as to compact into a dense mass under the action of the tamper and the strike-off board.

MECHANICAL OPERATIONS NECESSARY FOR CONSTRUCTION OF SUCCESSFUL CONCRETE FINISHES

Floor finish may be placed by two methods. It may be placed while the base is still plastic or the placing may be deferred until after the base has hardened. In either case good bond between the wearing course and the base can be obtained when the proper procedure is followed. All other operations are substantially the same for the two methods of floor construction.

Preparation of Hardened Base

When the first method mentioned is to be followed, the base course should be placed and roughly brought to grade. While the surface is still soft enough to receive and retain the impression, it should be brushed with a stiff bristled broom. This will effectively remove laitance, scum and inadequately embedded coarse aggregate. In addition it scores and pits the surface so as to provide mechanical bond for the topping. The base should be thoroughly cured for a period of at least ten days. During the interval between the placing of the base and the finish, the base should be protected from the deposition of grease, pitch, paint or any other foreign substance.

Immediately prior to the placing of the finished topping, the base course should be thoroughly cleaned by scrubbing with clean water and a stiff brush. If the base has been allowed to dry out it should be thoroughly wetted. If any foreign substances have been deposited on the floor that cannot be removed by scrubbing, the affected area should be chipped away and properly roughened with picks. No other method is so effective.

Acid treatments have little effect on dirty concrete. Only slightly soiled areas are amenable to this treatment and the desired roughened surface is not achieved.

After the surface of the base course is thoroughly cleaned, the top course may be applied as will be discussed in the text relating to the type of floor finish to be used.

In no case should the finish be placed on the base course until after the base has been cured for at least ten days. A longer period will be better, for the concrete in the base should be allowed to secure the greater portion of its initial shrinkage due to hardening before the topping is applied. If this is not done, the finished course may ultimately crack through no fault of its own.

Base Preparation for Monolithic Finish

If the second, or monolithic, method is to be followed, even greater care should be exercised in placing the

base which is struck off one inch below the finished grade, and while still plastic is topped with the wearing course. The wearing course is mixed with the minimum amount of water consistent with the necessary workability. If the base course is placed too wet, or unevenly struck off, so that free water will collect in puddles on the surface, the wearing course will absorb this excess water, greatly reducing the density, durability and strength of the finish.

It is of utmost importance that in this class of work the base course mixture be designed and placed with the minimum amount of mixing water that will give workability. Any water that may collect on the surface of the base course should be carefully removed before the wearing course is applied. Such free water is evidence that the concrete mixture in the base is improperly designed or carelessly mixed, and corrective measures should be taken at once to remedy the trouble. The entire effectiveness of the wearing course may be lost if the base course is not properly mixed and placed in a workable consistency in which there will be no appreciable separation of water from the mass.

Working operations should be carefully scheduled so that the wearing course will be placed within forty-five minutes after the base is placed.



BASE SLAB PROPERLY PREPARED FOR BONDING

A close view of the well-broomed surface of a concrete base slab. The conditions for bonding the wearing course to the roughened and cleaned base slab are excellent. Note the strip of finish in the background.



ROUGHENING BASE TO INSURE BOND

The concrete of the wearing course will adhere to the hardened base slab only when the surface of the latter is clean, free from laitance, scum, and suitably roughened. Brushing the partially hardened base with a stiff wire broom cleans and scores the surface, thus assuring uniformity of bond.

Design of Mixes for Floor Finishes

Mixes should be designed under the water-cement ratio law.* Under this system accurate control of the quantity of mixing water will result in more durable concrete having a high resistance to wear. The water should be carefully controlled so that not more than from $4\frac{1}{2}$ to 5 gallons of water per 94-pound sack of portland cement is used. The water or moisture in the aggregate should be carefully determined and this amount subtracted from that specified. Experience has shown that with the use of properly graded aggregate, the proportions of from 1-1- $1\frac{1}{2}$ to 1-1-2 will give satisfactory results when mixed with not more than $4\frac{1}{2}$ to 5 gallons of water.

Mixing water should be carefully measured at the mixer. Modern mixing equipment is usually equipped with water-measuring devices which may be set and locked, insuring the use of only the specified amount.

Workability of Concrete

Workability is an essential requirement of the water-cement ratio law. In structural concrete workability is measured by the ability of the mixed mass to flow readily into place without segregation and without excessive manipulation. Workability for concrete floor finishes is somewhat different. Therefore a mixture that is workable in structural concrete would in many cases be unsuited for a floor finish. Floor topping is carefully manipulated by troweling, rolling and other forms of compacting. For this reason a stiffer mixture is possible. Basically the principle is the same; there must be enough cement-water paste to

surround completely each aggregate particle to the exclusion of honeycombing and voids.

Considerably less fine aggregate is required in floor finish concrete than for normal structural concrete. This is because of two reasons. First, it is desired to expose as much of the extremely hard coarse aggregate by machine grinding as is possible so that it will take most of the abrasion and wear of service. Second, in compacting the floor finish by troweling, rolling or otherwise, the fine aggregate has the tendency to work to the surface more readily than the coarse. If there is an excess of fines, it will be difficult to bring the desired coarse particles to the surface, thus defeating the purpose of abrasion resistance.

Mixes ranging from 1-1- $1\frac{1}{2}$ to 1-1-2, with from $4\frac{1}{2}$ to 5 gallons of water per sack of cement, will usually produce workable concrete and allow finishing without excessive troweling. Gravel and crushed stone aggregate may produce concrete of different workability when used in the same proportions. Harshness should be corrected by decreasing the amount of coarse aggregate or by increasing the cement content. The specified amount of mixing water should not be increased to produce workability.

Compacting and Finishing

Due to the limitation of mixing water and the presence of a predominating amount of coarse particles



FLOATING AND TROWELING CONCRETE FLOOR TOPPING
Finishing operations play an important part in determining the utility, appearance and durability of the wearing course. Floating is performed for the purpose of filling up the hollows and compacting the concrete. Troweling not only compacts the wearing course but also produces a smooth surface so necessary for efficient trucking. The finishers are bearing down with full force on their trowels. This gives increased density.

of aggregate, floor finish concrete, when first deposited on the base, will have a somewhat open structure. It is necessary then to compact the concrete to secure a dense and impermeable finish. Screeding, floating, rolling and troweling are important operations upon which will depend the serviceability of the floor.

*The Portland Cement Association publishes the booklet "Design and Control of Concrete Mixtures" which thoroughly explains proportioning under the water-cement ratio law. This booklet may be had free of charge on request to the nearest office of the Association.

Screeding

Screeding is the operation that occurs immediately after the concrete has been dumped from the buggies or barrows and spread with shovels. It consists in moving a straightedge resting on the screed with a sawing motion, so as to strike off the finish at the right level. During the screeding process some compacting occurs; it is, however, comparatively slight.

Floating

Floating consists in rubbing the surface with wood or cork floats to fill up the hollows, and iron out the humps left after screeding. Under any condition, floating, whether it be done by hand or by machine, affects only the surface skin of the wearing course. The concrete below is not compressed appreciably and is still susceptible of compaction by heavy rolling.

Rolling

Rolling possesses all of the advantages of tamping without any of its drawbacks. It not only compacts the surface, but extends its action for a considerable distance below the surface. Rolling is perhaps the best method of securing maximum density when installing a heavy duty finish. Density is further assured by forcing into the finish additional coarse aggregate scattered over the surface during the rolling process.

Particular attention should be paid to areas at the base of columns and walls where it is difficult to make rolling effective. Any areas that cannot be reached by the roller should be thoroughly tamped.

Troweling

Troweling is the most important finishing and compacting operation performed on floor surfaces other than the ground finishes.



PRODUCING AN EVEN CONCRETE FLOOR FINISH

A most important operation where an even, plane finish is desired is the use of the long float to remove the inequalities frequently left by the short float. Notice the absence of water at the surface. The conditions of finishing are perfect in every respect.



ONE METHOD OF PRODUCING A COARSE-GRAINED FINISH

After the wearing course has been troweled, the surface is lightly brushed in one direction with a hair broom to produce small grooves. For floor areas subjected only to foot traffic, this method produces a suitable roughened finish; for areas subjected to trucking, coarse-grained finishes are obtained by the use of nonslip aggregates embedded near the surface.

Extremely wet surfaces should not be troweled, for this will tend to draw to the surface an excessive quantity of the fines suspended in a water medium. In turn this will result in a dusty floor as soon as the surface is subjected to wear. It will also promote shrinkage cracks in the surface.

Timely troweling is of the utmost importance. After the concrete has hardened sufficiently to prevent upward movement of fine particles, a reasonable number of passes of the trowel will improve the density of the finish. Excessive troweling should be avoided.

Grinding

In certain types of floors, the final finish is attained by grinding. This consists of removing with mechanical grinders the thin film of cement paste that covers the surface after the troweling operation, and exposing the coarse aggregates. Floor finish to be subsequently ground should have only one troweling.

Grinding should not be started until the concrete has hardened and cured a sufficient period of time to make

certain that the grinding operation will not tear the surface or break the bond between the aggregate and the surrounding cement-water paste.

Large double disk grinding machines electrically operated, such as are commonly used for finishing terrazzo floors, have been found highly economical.

Grinding is sometimes used to reduce the cost of troweling. In this case only a very light cut is taken over the surface of the floor, just sufficient to remove any skin of laitance which may be present, and to smooth out trowel marks. In some cases this method of finishing has cost no more than when the trowel was used to obtain the final finish. Its limitations lie in the inability of the operator to obtain a uniform appearing finish. Surfaces of different appearance may be expected to have variable resistance to wear, and are an indication of improperly designed mixtures.



TERRAZZO AND CONCRETE ART MARBLE WAINSCOTING

The requirements of sanitation and durability essential in an ice cream plant have been attained by the Cunningham Ice Cream Company, Chicago, by the use of ground and polished concrete. In addition, this floor has a pleasing appearance, and is easy to clean and keep clean. Treatment with paraffin and periodical application of a good floor wax gives a surface that is resistant to the action of milk acids.

Factors that will tend to reduce the effectiveness of a ground finish floor surface are:

- Improper mixtures, especially with the use of an excessive water-cement ratio.

- Improper grading of aggregates, with an excessive amount of fine particles.

- Improper preliminary finishing with screed, float and roller, which results in an irregular surface.

Curing

There are many methods of curing concrete floors. The ponding method is often used in which the floor slab is surrounded by small dikes of sand and the en-

closure kept filled with water. Frequent sprinkling of the surface and covering the exposed surface with wet sand or wet burlap are other ways of providing curing. The coverings should be placed as soon as this can be done without marring the surface and they should be kept continuously wet by frequent sprinkling.

In cold weather construction when artificial heating devices are used, special precautions are required. The high temperatures near the heating devices cause rapid drying out unless the concrete is well protected. Heaters should be insulated from the floor by a three or four-inch layer of sand that extends for a distance of at least four feet on all sides. The sand should be kept saturated with water at all times. Tubs of water should be placed near each heater to provide moisture for the air.

Cleaning Finishes Prior to Use

Immediately after the concrete floor is given its final finish, the surface is free from dirt. It should be protected from the accumulation of building debris until the completion of the structure, and turned over to the owner in a clean condition.

To remove accumulated dirt or foreign substances, the surface should be well swept with a stiff broom, and thoroughly scrubbed with white soapsuds. It would be well to employ the use of a scrubbing machine fitted with a wire brush or fine steel wool. The suds with suspended dirt should be mopped up and the surface flushed with clean warm water and again mopped.

Much of the trouble encountered with new floors dusting has been caused by the delivery of the floor to the owner in a dirty condition. Subsequent traffic grinds this dirt into the floor where its presence causes the dust frequently attributed to the floor finish.

Cold Weather Precautions

Concrete hardens very slowly at temperatures below 60°F. and practically not at all at freezing temperatures. When placing concrete in winter there is danger that freshly placed concrete will freeze. In concrete floors the condition is aggravated by the relatively thin section of the mass. Special precautions are required for all cold weather work.

In addition to heating aggregates and mixing water, the space above and below the floor being placed should be enclosed and the temperature maintained at or above 60°F. This should continue for at least 5 days after the floor is placed. Uneven temperatures above and below the slab will frequently cause unequal contraction and expansion on the two faces of the slab resulting in cracks.

Heating the mixing water and aggregate is a satisfactory method of protecting concrete. On leaving the mixer, the mass should be free from ice or frozen lumps and should have a temperature of not less than 60 nor more than 110 degrees.

HARDENER TREATMENTS

The durability and effectiveness of a floor finish depends primarily upon the observance of fundamental rules in making, placing, curing and finishing concrete. Under certain conditions it may be advisable to use a hardener treatment on the surface of the floor. Such treatments are not cure-alls for poor workmanship or careless practice. Surface treatments may improve some surfaces but they will not make perfect the wearing qualities of a poorly built floor.

These compounds tend to fill pores in the finish and produce a more dense topping either by crystallizing or by acting as a glue. Magnesium fluosilicate, sodium silicate, aluminum sulphate, zinc sulphate and various oils, gums, resins and paraffins are substances used in arresting the dusting of defective floor finish.

Fluosilicate Treatment

The fluosilicates of zinc and magnesium, when dissolved in water, have been used with fair success for hardening defective concrete finish. In making up the solutions, $\frac{1}{2}$ pound of the fluosilicate should be dissolved in one gallon of water for the first application and 2 pounds to each gallon for subsequent applications. The concrete floor must be clean and free from plaster, oil, paint or other foreign substances, otherwise the solutions will not penetrate sufficiently to react. For the same reason the surface must be absolutely dry. After the floor has dried, the second application

may be made. About 3 or 4 hours are generally required for absorption, reaction and drying, though this will depend upon the weather. In this treatment, with the average floor surface, one gallon of the liquid will cover approximately 130 square feet. Care should be taken to mop the floor shortly after drying to remove incrustated salts, otherwise white stains may be formed.

Sodium Silicate Treatment

When sodium silicate is used, it is applied in a 20% solution in two or more coats twenty-four hours apart. Ordinarily the sodium silicate requires considerable time to dry before the floor can be used. Commercial sodium silicate varies in strength from 30 to 40% solution. It is quite viscous and requires thinning with water before it will penetrate the floor. It has been found satisfactory to dilute each gallon of the silicate with three gallons of water. Each gallon of the resulting solution will cover approximately 200 square feet of floor surface. The floor should be thoroughly cleaned of all foreign matter, and should be dry before the first application of the silicate solution.

Aluminum Sulphate Treatment

This treatment consists in one or more applications of solutions of aluminum sulphate to the clean, dry surface. The solution is made up in a wooden barrel



OUTDOOR CONCRETE DANCE FLOOR, EXMOOR COUNTRY CLUB, HIGHLAND PARK, ILLINOIS

The permanence and adaptability of concrete make it the best material for outdoor dance floors. Either troweled or ground finishes are suitable. Beautifully colored effects may be obtained by using colored aggregates or pigments in the concrete. Shankland & Pingree, Architects and Engineers.



SHIPPING PLATFORM, HILLIARD & MERRILL PLANT,
LYNN, MASS.

This concrete shipping platform is in perfect condition after seven years of heavy trucking. The excellent results are due to the use of a low water-cement ratio in the topping. The concrete wearing course was compacted by rolling and was finished by grinding.

or stoneware vessel and the water should be acidulated with not more than one teaspoonful of commercial sulphuric acid for each gallon of water. The sulphate does not readily dissolve and requires occasional stirring for a few days until the solution is complete. About $2\frac{1}{2}$ pounds of the powdered sulphate will be required for each gallon of water and one gallon of the solution should cover about 100 square feet of floor surface. For the first treatment the solution may be diluted with twice its volume of water. Twenty-four hours after this application the stronger solution may be used, and twenty-four hours should elapse between subsequent applications.

Zinc Sulphate Treatment

This treatment consists of the application of about 16% solution of zinc sulphate made acid with a teaspoonful of commercial sulphuric acid to every gallon. The mixture is applied in two coats, the second coat



PRELIMINARY FINISHING ON HEAVY
DUTY TERRAZZO

The wearing course of this heavy duty terrazzo floor in the Hilliard & Merrill Plant, Lynn, Mass., contains a high percentage of crushed stone. The concrete was compacted by rolling. The finishers in the foreground are smoothing the surface to permit grinding with terrazzo machines.

being applied four hours after the first. The surface should be scrubbed with hot water and mopped dry just before the application of the second coat. This treatment gives the floor a darker appearance.

Admixtures

There are on the market a number of compounds, which are widely advertised for inclusion in the body of the concrete. Instructions for the use of these compounds call for many of the methods and practices which are known to be essential for successful concrete floors built without the use of admixtures. Poor workmanship or improper methods or materials cannot be compensated for by the use of integral compounds. Admixtures containing chemicals may interfere with the chemical action between the cement and water. For this reason it is necessary to know definitely by experience that the admixture proposed for use will react favorably with cement.

HEAVY DUTY FLOOR FINISH

Heavy duty floors are designed for heavy trucking and rough service, such as that encountered on shipping platforms and docks, warehouses, manufacturing plants and similar establishments.

For floors to be subjected to heavy duty, the recommended type of finish is that which is placed after the supporting base slab has hardened. This is commonly known as the One-Inch Bonded Topping. This type of construction facilitates control of the quality of the concrete for the wearing course. The base having previously hardened, no free water can escape from

the base into the topping and increase the water-cement ratio of the finish course. At the time of placing the topping the structure is enclosed. In the winter months, heat in the surrounding area is more uniform and proper temperatures are easier to maintain during the placing and curing periods. Screeds may be set with greater accuracy, which is an asset in attaining proper levels in the finished floor. (Less protection from construction abuse will be required.) These and other advantages may be gained by the use of this type of bonded finish.

TYPICAL WORKING SPECIFICATIONS FOR HEAVY DUTY FLOOR FINISH

(One-inch topping placed after the base has hardened)

Note to Specification Writer: The notes appearing at the end of paragraphs 2, 3, 5 and 6 pertain to wearing courses that are to be finished by grinding. These notes should be used in lieu of their respective paragraphs when writing specifications for a ground finish.

1. Base Slab

The surface of the structural base slab shall be finished reasonably true and struck off at a level approximately one inch below the required finish grade.

As soon as the condition of the concrete base permits, and before it has fully hardened, all dirt, laitance and loose aggregate shall be removed from the surface by means of a wire broom, which shall leave the coarse aggregate slightly exposed, or the surface otherwise roughened to improve bond with the topping.

When it is impossible to remove laitance and roughen the slab by brooming, the surface shall be cleaned and prepared for bond by chipping after the base has hardened.

Just prior to placing the finish, the base slab shall be thoroughly cleaned by scrubbing, to the satisfaction of the engineer.

2. Aggregates

Both fine and coarse aggregates shall be used in the finish. Fine aggregate shall consist of clean, hard sand or crushed stone screenings free from dust, clay, loam or vegetable matter. All particles shall pass a $\frac{1}{4}$ -inch sieve and shall be graded from fine to coarse with the coarse particles predominating. Not more than 5 per cent shall pass a 100 mesh, and not more than 10 per cent shall pass a 50 mesh sieve.

Coarse aggregate shall consist of clean, hard pea gravel, or crushed stone, free from dust, clay, loam or vegetable matter and from coatings which will tend to weaken the bond. It shall contain no soft, flat or elongated fragments, and shall be graded from $\frac{1}{4}$ to $\frac{3}{8}$ inch; all particles shall pass a $\frac{1}{2}$ -inch mesh.

All aggregate shall be selected with care. Coarse aggregate shall be of an approved character, and samples of proposed material shall be submitted to the engineer for approval prior to use.

Note: When the topping is to be finished by grinding, the coarse aggregate shall be hard, tough, crushed stone graded as recommended for terrazzo. See page 16, item 2.

3. Mixture

The mixture shall be 1 part of portland cement, 1 part of fine aggregate and 2 parts of coarse aggregate by volume. This nominal mix may be slightly varied, depending upon the local conditions, and as the engineer may direct. If the aggregate is very coarse, the gravel or stone should be reduced to $1\frac{1}{2}$ parts. In no case shall the volume of the coarse material be more than twice the volume of the fine.

The mixture shall be determined by the engineer and once established shall not be changed except upon his written order.

Not more than 5 gallons of mixing water including the moisture in the aggregates shall be used for each sack of portland cement in the mixture.

Note: When the topping is to be finished by grinding, no sand shall be used. One part of cement by volume shall be mixed with 3 parts crushed stone.

4. Consistency

The concrete shall be of the driest consistency possible to work with a sawing motion of the strike-off board, or straight-edge. Changes in consistency shall be obtained by adjusting the proportions of fine and coarse aggregate within the limits specified. In no case shall the specified amount of mixing water be exceeded.

5. Placing and Compacting

The base slab shall be thoroughly wetted just prior to the placing of the finish, but there shall be no pools of water left standing on the wetted surface. A thin coat of neat cement grout shall be broomed into the surface of the slab for a short distance ahead of the topping. The wearing course shall be immediately applied before the grout has hardened, and brought to the established grade with a straightedge.

Note: When the surface is to be finished by grinding, the wearing course shall be compacted with rollers or vibrators. Rollers shall be of sufficient weight to compact the concrete thoroughly. When the engineer may direct, coarse aggregate shall be uniformly scattered over the surface during rolling.

6. Finishing by Troweling

After striking off the wearing course to the established grade, it shall be compacted with a wood float. The surface shall be tested with a straightedge to detect high and low spots which shall be eliminated. Floating shall be followed by steel troweling after the concrete has hardened sufficiently to prevent excess fine material from working to the surface. The finish shall be brought to a smooth surface free from defects and blemishes. No dry cement or a mixture of dry cement and sand shall be sprinkled directly on the surface of the wearing course to absorb moisture or to stiffen the mix. After the concrete has further hardened additional troweling may be required. This shall be done as may be directed by the engineer.

Note: Surfaces to be ground shall be swept with soft brooms after rolling to remove any water and surplus cement paste that may be brought to the surface. The wearing course shall then be floated and once lightly troweled, but no attempt shall be made to remove all trowel marks.

7. Finishing by Grinding

After the wearing course has hardened sufficiently to prevent dislodgment of aggregate particles, it shall be ground down with an approved type of grinding machine shod with free, rapid cutting carborundum stones to expose the coarse aggregate. The floor shall be kept wet during the grinding process. All material ground off shall be removed by squeegeeing and flushing with water.

Air holes, pits and other blemishes shall then be filled with a thin grout composed of one part of No. 80 grain carborundum grit and one part of portland cement. This grout shall be spread over the surface and worked into the pits with a steel straight-edge, after which the grout shall be rubbed into the floor surface with the grinding machine.

After all patch fillers have hardened for seven days the floor surface shall receive a second or final grinding to remove the film and to give the finish a polish. It shall then be thoroughly washed and all surplus material removed.

8. Curing and Protection

All freshly placed concrete shall be protected from the elements and from all defacement due to building operations. The contractor shall provide and use when necessary tarpaulins to completely cover or enclose all freshly finished concrete.

If at any time during the progress of the work the temperature is, or in the opinion of the engineer will, within twenty-four (24) hours, drop to 40 degrees Fahrenheit, the water and aggregate shall be heated and precautions taken to protect the work from freezing for at least five (5) days.

As soon as the concrete has hardened to prevent damage thereby, it shall be covered with at least one (1) inch of wet sand, or other covering satisfactory to the engineer, and shall be kept continually wet by sprinkling with water for at least ten (10) days.

LIGHT DUTY FLOOR FINISH

Light duty floors are designed to take ordinary foot traffic or light, rubber-tired trucking. Office buildings, where floors are not to be covered, floors in hospitals and schools (excepting basement floors) are the type that would come under this classification.

For light duty floors, the finish may be placed mono-

lithically with the base, that is, before the base has hardened. This type of finish is known as the One-Inch Monolithic Topping, and is usually installed as the building operations progress. Greater care is required to protect the work from the elements, and from too early use of the finished floor.

TYPICAL WORKING SPECIFICATIONS FOR LIGHT DUTY FLOOR FINISH

(One-Inch Monolithic Topping Trowel or Ground Finish)

1. Base Slab

The surface of the structural base slab shall be struck off reasonably true and at a level approximately one inch below the grade of the finished floor.

All water, laitance, or dirt that may work to the surface of the base slab shall be removed before the topping is placed.

2. Aggregates

Both fine and coarse aggregates shall be used in the finish. Fine aggregate shall consist of clean, hard sand or crushed stone screenings, free from dust, clay, loam or vegetable matter. All particles shall pass a $\frac{1}{4}$ -inch sieve and shall be graded from fine to coarse, with the coarse particles predominating. Not more than 5 per cent shall pass a 100 mesh, and not more than 10 per cent shall pass a 50 mesh sieve.

Coarse aggregate shall consist of clean, hard pea gravel or crushed stone free from dust, clay, loam or vegetable matter and from coatings which will tend to weaken the bond. It shall contain no soft, flat or elongated fragments, and shall be graded from $\frac{1}{4}$ to $\frac{3}{8}$ inch; all particles shall pass a $\frac{1}{2}$ -inch mesh.

All aggregate shall be selected with care. Coarse aggregate shall be of an approved character, and samples of proposed material shall be submitted to the engineer for approval prior to its use in the work.

3. Mixture

The mixture shall be 1 part of portland cement, 1 part of fine aggregate and 2 parts of coarse aggregate by volume. This nominal mix may be slightly varied, depending upon local conditions and as the engineer may direct. If the aggregate is very coarse, the gravel or stone should be reduced to $1\frac{1}{2}$ parts. In no case shall the volume of the coarse material be more than twice the volume of the fine.

The mixture shall be determined by the engineer and after once established shall not be changed except upon his written order.

Not more than 5 gallons of mixing water, including the moisture in the aggregates, shall be used for each sack of portland cement in the mixture.

4. Consistency

The concrete shall be of the driest consistency possible to work with a sawing motion of the strike-off board or straight-edge. Changes in consistency shall be obtained by adjusting the proportions of aggregate and cement. In no case shall the specified amount of mixing water be exceeded.

5. Placing and Compacting

The concrete topping shall be deposited on the base within 45 minutes after the concrete base is in place and before the base has appreciably hardened.

6. Finishing by Troweling

After striking off the wearing course to the established grade it shall be compacted with a wood float. The surface shall be

tested with a straightedge to detect high and low spots, which shall be eliminated. Floating shall be followed by steel troweling after the concrete has hardened sufficiently to prevent excess fine material from working to the surface. The finish shall be brought to a smooth surface free from defects and blemishes. No dry cement or a mixture of dry cement and sand shall be sprinkled directly on the surface of the wearing course to absorb moisture or to hasten the hardening. After the concrete has further hardened additional troweling may be required. This shall be done as may be directed by the engineer.

7. Finishing by Grinding

Note to Specification Writer: This paragraph to be used in lieu of paragraph 6 when **ground finish** is desired.

After the topping is struck off to a true and even surface it shall be thoroughly compacted with a wood float until all depressions and irregularities are eliminated. The surface shall then be once lightly troweled and allowed to harden. During the hardening period the surface shall be protected as required in item (8) of this specification.

After the wearing course has hardened sufficiently to prevent dislodgment of aggregate particles, it shall be ground down with an approved type of grinding machine shod with free, rapid cutting carborundum stones. Only a light cut shall be taken with the grinder, and care shall be observed to produce a finish of uniform appearance. The floor shall be kept wet during the grinding process. All material ground off shall be removed by squeegeeing and flushing with water.

Air holes, pits and other blemishes shall then be filled with a thin grout composed of neat cement paste. This grout shall be spread over the area and worked into the floor surface with the grinding machine.

After all patch fillers have hardened, the floor surface shall receive a second or final grinding to remove the film. It shall then be thoroughly washed and all surplus material removed.

8. Curing and Protection

All freshly placed concrete shall be protected from the elements, and from all defacement due to building operations. The contractor shall provide and use when necessary tarpaulins to cover completely or inclose all freshly finished concrete.

If at any time during the progress of the work the temperature is, or in the opinion of the engineer will, within twenty-four (24) hours, drop to 40 degrees Fahrenheit, the water and aggregate shall be heated and precautions taken to protect the work from freezing for at least five (5) days.

As soon as the concrete has hardened to prevent damage thereby, it shall be covered with at least one (1) inch of wet sand, or other covering satisfactory to the engineer, and shall be kept continually wet by sprinkling with water for at least ten (10) days.

DECORATIVE CONCRETE FLOOR FINISH

Terrazzo

Terrazzo floor finishes offer the greatest possibilities for decorative effects. Made with crushed marble aggregate, a great variety of color schemes are made possible. Coloring pigments are sometimes added to the cement to obtain shades and color effects not possible with the natural color of stone or marble.

Divided into patterns and designs with the use of brass strips, terrazzo floor finishes may be made to harmonize with any style of interior fittings.

Properly installed, terrazzo finishes of desired utility afford excellent wearing surfaces for floors in banks, hotels, office buildings, churches and other public or social buildings.

In decorative floor finishes, cracks from any source are particularly objectionable. Shrinkage cracks are largely eliminated or localized by the brass dividing strips that form the pattern of the floor. Structural cracks which are usually caused by a crack in the base slab may be eliminated by constructing the wearing course without bond with the base. This may be done by separating the two courses with a layer of sand covered with tar paper. The sand provides a bed for the terrazzo finish, and cracks originating in the base

slab either from settlement, contraction or vibration do not appear at the surface of the wearing course.

The recommended type of terrazzo floor finish is constructed by first placing a sand cushion uniformly $\frac{1}{4}$ of an inch thick on top of the hardened base slab. This is covered with a layer of tar paper upon which is deposited a course of 1-3 mortar, $1\frac{1}{4}$ inches thick. The metal strips are inserted in the mortar bed, dividing the floor into the desired patterns.

When the mortar bed has hardened sufficiently, a terrazzo mixture $\frac{3}{4}$ of an inch thick, composed of one



TERRAZZO FLOOR, DENVER NATIONAL BANK, DENVER

Metal dividing strips of both irregular and straight patterns permit a wide range in design and color effects. The monogram-like figures in the center panel and the border designs of this beautiful lobby floor are worthy of particular attention. W. E. and A. A. Fisher, Architects.



TERRAZZO FLOOR, NEW BISMARCK HOTEL, CHICAGO

A beautifully executed paneled pattern in different colors. Brass dividing strips assist in eliminating or localizing shrinkage cracks. Rapp & Rapp, Architects, Chicago.

part portland cement and 3 parts marble chips, is applied. This terrazzo layer is then rolled until thoroughly compacted. Additional chips may be added during the rolling process, so that the finished floor surface will show approximately 85% marble.

After curing for several days, the terrazzo layer is ground down and highly polished, which gives the floor a pleasing appearance and a finish that is sanitary and easy to keep clean.

The successful construction of a satisfactory terrazzo floor finish requires skilled labor working under an adequate specification, and the work should be entrusted to floor specialists whose experience will have shown them capable of rendering the class of workmanship desired.

TYPICAL WORKING SPECIFICATIONS FOR TERRAZZO FLOOR FINISH

1. Base Slab

The surface of the base slab shall be struck off reasonably true at a level not less than $2\frac{1}{4}$ inches below the required finish grade.

2. Aggregates

No fine aggregate or sand shall be used in the terrazzo finish. The coarse aggregate shall be (insert here the kind and color of marble chips desired). The coarse aggregate shall be graded in three sizes: $\frac{1}{8}$ inch, $\frac{1}{4}$ inch and $\frac{1}{2}$ inch.

3. Mixtures

The mortar base for the terrazzo finish shall be mixed in the proportions of one part of portland cement to 3 parts of clean, coarse sand, mixed with not less than 6 gallons of water per sack of portland cement.

The terrazzo mixture shall be one part of portland cement and 3 parts of stone chips.

Not more than 4 gallons of mixing water, including the moisture in the aggregate, shall be used for each sack of portland cement in the mixture.

4. Consistency

The terrazzo concrete shall be of the driest consistency possible to work with a sawing motion of the strike-off board or straight-edge. Changes in consistency shall be obtained by adjusting the proportions of aggregate and cement. In no case shall the specified amount of mixing water be exceeded.

5. Placing

Before placing the mortar base and the terrazzo finish, the surface of the structural concrete slab shall be covered with a uniform layer of fine sand $\frac{1}{4}$ inch thick, and covered with an approved tar paper.

The mortar base shall be at least $1\frac{1}{4}$ inches thick and shall be screeded to an even surface $\frac{3}{4}$ of an inch below the finished floor level.

Metal dividing strips about $1\frac{1}{2}$ inches wide, at least 20 gauge, shall be inserted in the mortar or supported on the slab to conform to the designs specified by the architect. The top of the strips shall be at least $\frac{1}{32}$ of an inch above the finished level of the floor.

When in the opinion of the engineer the mortar base has hardened sufficiently to withstand rolling, the terrazzo mixture shall be placed to the level of the tops of the dividing strips.

6. Finishing

After striking off to the finished level, the concrete topping shall be rolled length and crosswise so as to secure thorough compaction of the stone chips and cement paste. Additional stone chips of the larger size shall be spread over the topping during rolling until 85 per cent of the finished surface shall be composed of stone. Immediately after rolling, the surface shall be floated and troweled once. No attempt shall be made to remove trowel marks.

After the terrazzo concrete has hardened enough to prevent dislodgments of aggregate particles, it shall be ground down with an approved type of grinding machine shod with free, rapid cutting carborundum stones to expose the coarse aggregate. The floor shall be kept wet during the grinding process. All material ground off shall be removed by squeegeeing and flushing with water.

Air holes, pits and other blemishes shall then be filled with a thin grout composed of neat cement paste. This grout shall be spread over the surface and worked into the pits. After all patch fillers have hardened for seven days the floor surface shall receive a second or final grinding to remove the film of cement paste and to give the floor a polish. It shall then be thoroughly washed and all surplus material removed.

7. Curing and Protection

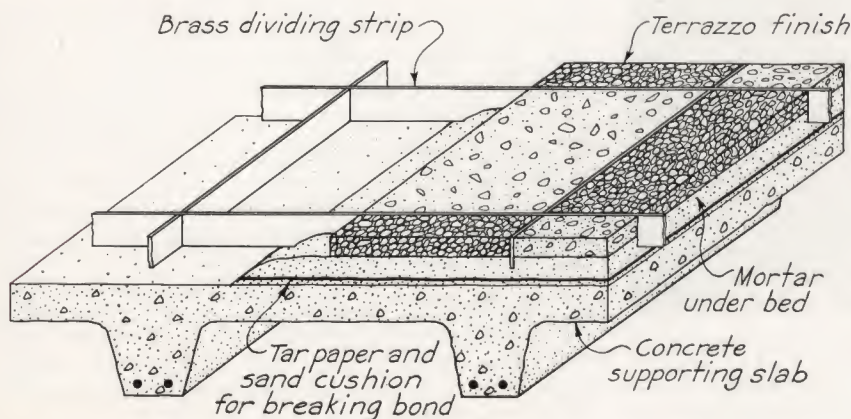
All freshly placed concrete shall be protected from the elements and from all defacements due to building operations. The contractor shall provide and use when necessary tarpaulins to cover completely or enclose all freshly finished concrete.

If at any time during the progress of the work the temperature is, or in the opinion of the engineer will, within twenty-four (24) hours, drop to 40 degrees Fahrenheit, the water and aggregate shall be heated and precautions taken to protect the work from freezing for at least five (5) days.

As soon as the concrete has hardened to prevent damage thereby, it shall be covered with at least one (1) inch of wet sand, or other covering satisfactory to the engineer, and shall be kept continually wet by sprinkling with water for at least ten (10) days.

8. Cleaning

After removing all loose material, the finish shall be scrubbed with warm water and soft soap, and mopped dry.



ISOMETRIC CROSS-SECTION OF A WELL-CONSTRUCTED TERRAZZO FINISH

This shows the relative position of the base slab, sand cushion and tar paper for breaking bond, the under mortar bed and the finish course. With broken bond, minor structural cracks originating in the base will not be carried through to the finish. Brass dividing strips permit the division of the floor into varicolored patterns and also tend to eliminate or localize shrinkage cracks in the topping.

OTHER TYPES OF DECORATIVE FLOOR FINISHES

Concrete Tile and Art Marble Floor

A beautiful decorative finish may be attained by the use of precast concrete tile and art marble. Wearing surfaces made of these materials are particularly adaptable for residences, office buildings, hotels, churches and similar structures.

Concrete and art marble tile may be secured in many colors, shapes and patterns, and special individual designs can be made to order. Tile and art marble when made by reliable manufacturers consists of concrete carefully proportioned and cured under efficient supervision and possesses all the features found in a well-constructed concrete floor finish of comparable utility.

To install concrete or art marble tile, the base course should be roughly brought to within 2 or $2\frac{1}{4}$ inches of the finished grade and allowed to harden. A 1-3 mortar is placed on the dampened base and the tile is laid in the desired pattern. Before the tile are laid, they should be soaked in water for 10 to 20 minutes, and then allowed to dry for about the same length of time; the object being to have them uniformly damp, but not saturated with water.

Laying of the tile should begin in the center of the area, so that the opposite sides will require the same number of tile, and so that the border designs will work out symmetrically.

Tile should be laid by experienced labor and under the manufacturer's specifications.



CONCRETE ART MARBLE FLOOR, COVENANT CLUB, CHICAGO

Attractive color effects secured by the use of concrete tile laid in a conventional pattern. This type of floor is particularly adaptable to residences as well as public buildings. W. W. Ahlschlager, Chicago, Architect.

Integrally Mixed Color Pigments

It is frequently desired to install concrete floor finishes of uniform color. This may be satisfactorily accomplished by mixing pigment integrally with the concrete finish. A wide choice in the variety of colors makes possible floors that will harmonize with any architectural or interior decorative scheme. The floor may be marked off into conventional patterns by the use of an ordinary grooving tool, or by the use of a power-driven carborundum disc cutting appliance.

Mixing of mineral coloring pigments with the ingredients of the floor finish should be resorted to on the job only when prepared machine-mixed materials are not available in the desired colors. Manufacturers' specifications should be carefully followed.

If it is desired to make the colored mixture on the job, the following table of colors will be found helpful in attaining the desired shades.

TABLE OF COLORS TO BE USED
IN CONCRETE FLOOR FINISH

Amounts of pigments given in table are approximate only. Test samples should be made up to determine exact quantities required for the desired color and shade.

Color Desired	Commercial Names of Colors for Use in Cement	Pounds of color required for each bag of cement to secure	
		Light Shade	Medium Shade
Grays, blue-black and black	Germantown Lampblack* or	$\frac{1}{2}$	1
	Carbon Black* or Black	$\frac{1}{2}$	1
	Oxide of Manganese* or	1	2
	Mineral black	1	2
Blue	Ultramarine blue	5	9
Brownish red to dull brick red			
Bright red to vermilion	Red oxide of iron	5	9
Red sandstone to purplish red	Mineral turkey red	5	9
Brown to reddish-brown	Indian red	5	9
Buff, colonial tint and yellow	Metallic brown (oxide)	5	9
Green	Yellow ochre or	5	9
	Yellow oxide	2	4
Green	Chromium oxide or	5	9
	Greenish blue ultramarine	6	..

*Only first quality lampblack should be used. Carbon black is of light weight and requires very thorough mixing. Black oxide or mineral black is probably most advantageous for general use. For black use 11 pounds of oxide for each bag of cement.



CAST-IN-PLACE CONCRETE FLOORS FOR APARTMENT BUILDINGS AND RESIDENCES

The integrally colored concrete floor finish in this building has been marked off in squares with a cutting tool. Highly polished with wax, this type of floor harmonizes with the quiet dignity of the interior decoration.

Painted Floor Finish

Concrete floor finishes may be painted to attain any color effect.

Before painting it is necessary that the concrete surface be thoroughly clean and dry. It is also necessary to neutralize the alkalinity by brushing the surface with a zinc sulphate solution made by dissolving 4 pounds of the chemical in one gallon of water. This solution may be applied with a paint brush, mop or squeegee. The solution should be allowed to dry and react with the concrete finish for at least 48 hours before paint is applied.

Paints having a vehicle composed of pure linseed, or a mixture of linseed and china wood oils in which is suspended an abrasion-resisting pigment of the desired color, should give satisfactory results. The first paint coat should be diluted with turpentine or naphtha. The second and third coats may be applied just as they come from the can.

Stained Floor Finish

If a mottled or multi-tone effect is desired, the finished surface may be stained with an inorganic material.

In staining finished floors, inorganic coloring materials are applied to the hardened and cleaned surface with mops or brushes, and permitted to react with the concrete. At times several applications are necessary before the desired effect is attained. Floors treated in this manner will have a mottled appearance. After the stain has thoroughly dried, the floor surface should be given a hardener treatment and polished with wax.

Floors designed and constructed for heavy duty service will not absorb enough staining material to produce a permanent change in color.

Concrete Finish for Dance Floors

Well-constructed concrete floor finishes, when waxed or highly polished, make excellent surfaces for dancing. Hotels, summer gardens, country clubs and similar organizations have found concrete the ideal material for dance floors out-of-doors.

The main requirements for concrete dance floors are smoothness and hardness. Either troweled or terrazzo finishes are suitable. In the case of troweled finish, particular care should be taken to secure a surface free from rippled and rough spots. Additional troweling at the time the concrete is hard enough to produce a ring as the trowel passes over it will greatly assist in producing a smooth, hard surface.

Dance floors in the open placed directly on the ground require special precautions, due to exposure to a wide range of temperature variations and extreme conditions of weathering. The concrete base or supporting slab for the finish should be placed on a well-drained cinder fill at least 9 inches thick. The base slab should be at least 6 inches thick and composed of a workable mixture in the proportion 1-2-3. Temperature reinforcing should be placed directly on top of the unhardened base slab and the finish course applied immediately. Concrete for dance floors in the open should be constructed in the same manner and under the same specifications as outlined for the one-inch Monolithic Topping, Trowel-finish Method, page 14.

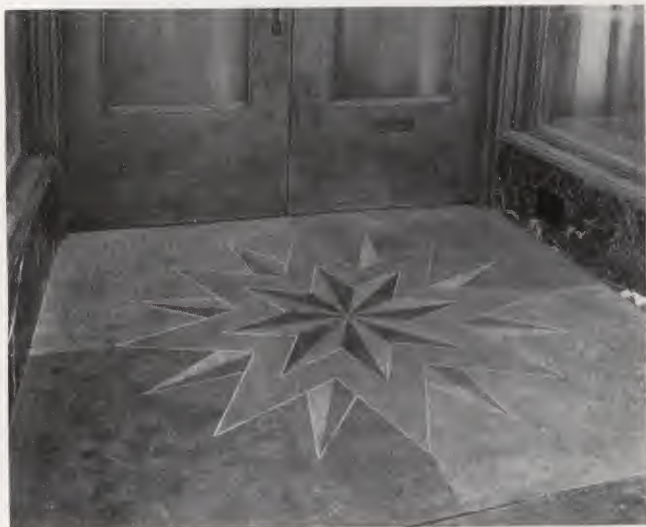
Temperature reinforcing should consist of at least $\frac{1}{4}$ -inch bars, spaced at 6-inch centers extending in both directions, or an equivalent area of steel in wire fabric or expanded metal. In unstable earth, structural reinforcing may be needed in the lower face of the base slab.

Dance floors of exceptional area or irregular and unusual shape require special consideration and should be designed by a competent engineer.

Any one of the following methods has been found satisfactory for polishing concrete dance floors.

A treatment with paraffin wax dissolved in turpentine followed by a coating of powdered wax.

Scrubbing the floor with a strong soap solution and



VARICOLORED FLOOR FINISH, MODERNISTIC DESIGN

The troweled finish requires accurate placement of brass strips in order that they will be flush with the wearing surface. Four different colored concretes were used in the design of this floor in the Cooper Building, Los Angeles. Morgan, Walls & Clements, Architects.

mopping, followed by occasional application of powdered soap after the floor is dry.

Polishing the floor with powdered boric acid.

Coarse-Grained Concrete Floor Finish

In certain locations, a nonslip finish is desired. This may be accomplished by roughening the finished surface immediately after the final troweling or by use of nonslip aggregates in the concrete mixture.

Nonslip aggregates may be mixed with the concrete, or sprinkled on the surface of the placed topping just prior to finishing. When mixed with the concrete a greater amount of the aggregate is required, but a more uniform distribution is attained. Approximately $\frac{3}{4}$ to 1 pound of nonslip aggregate is required for each square foot of finished surface.

When applied only to the surface of the floor finish, from $\frac{1}{4}$ to $\frac{1}{2}$ of a pound of abrasive is used. The aggregate should be uniformly scattered over the unhardened topping just prior to compacting. The sur-

face should then be carefully finished by grinding or as may be specified for the type of floor being constructed. This method places the nonslip aggregate only at the surface where it is needed.

Monolithic Dust Coat Finish

(For floors that are to be covered with linoleum, composition tile, or other similar materials.)

The dust coat method of finishing concrete floors is sometimes used when the floor is to be covered with a wearing surface of other materials. While it is an economical type of finish suitable for this purpose, it is not satisfactory for uncovered floors directly subjected to traffic.



FLEXIBILITY IN DESIGN AND VARIATION IN COLOR

This concrete floor in the Cooper Building, Los Angeles, illustrates the great flexibility in design and color possible with concrete. Morgan, Walls & Clements, Architects.

The structural slab surface is struck off reasonably true at the required floor level and excess water, laitance or dirt removed. A mixture of dry materials, consisting of one part of portland cement and two parts of coarse, clean sand, is dusted on the unhardened concrete in a uniform layer not over $\frac{1}{8}$ of an inch thick. When the dry materials have absorbed moisture from the slab and the concrete has hardened enough to allow finishing, it is floated and troweled to unite the dust coat with the base and give an even surface free from air holes, depressions and other blemishes. The floor should then be protected and cured as recommended for other types.

DURABLE CREAMERY FLOORS

The lactic acid found in some milk products reacts unfavorably with concrete. The rate of attack will depend upon the quality of the concrete, but in the case of dense floor finish, described under "Heavy Duty," the reaction is very slow. Complete immunity from acid action may be obtained by using one of the following surface treatments. Irrespective of which method is used, the concrete floor is first allowed to dry out thoroughly at the end of the curing period before proceeding with the acidproofing.

The simpler treatment of the two consists in applying warm linseed oil to the floor and working it around with a mop or brush. In order to facilitate penetration into the concrete the oil should be thin. No attempt need be made to build up a surface film. All excess oil on top may be removed with a squeegee before the oil begins to get tacky. When properly applied the oil will effectively seal the floor surface.

The other treatment consists in applying a paraffin mixture to the surface of the floor. Experience has shown that the paraffin should have a melting point of 150° F. It is made into a paste by melting 4 parts by weight with 1 part of turpentine and 16 parts of toluol. Toluol is a common solvent obtained from coal tar, and may be purchased from any chemical supply house or wholesale druggist. The mixture is spread on the floor and allowed to penetrate for 24 hours. At the end of this time the residual layer should be driven into the concrete by heat. A free flame should not be used due to fire hazards; hot irons will be found safe and

effective in forcing the paraffin into the pores and capillaries of the finish for some distance below the surface.

After either treatment, the floor should be given a good waxing with any standard floor wax suited for this purpose. As the wax film is worn away through use, it is replaced by a fresh coating with the use of a polishing machine. Neither of these methods of acid-proofing creamery floors will change the color of the finish appreciably.

Concrete floor finish in receiving rooms and unloading platforms of creameries may be made resistant to impact by embedding correctly designed steel grating in the floor in such a way that the top of the metal is flush with the wearing surface. Grating consists of strips of steel held together by rivets or by tie rods, and should be placed on the concrete base before it has hardened. The concrete should be stiff enough so that the grating will be held true to grade and will not sink into the base. Spaces in the grating should be filled with the same quality of concrete as that used in the rest of the wearing course. Particular care should be taken in placing the concrete between the metal strips of the grating so as to surround all metal surfaces. Tapping of the metal with a mallet will help to secure good bond by making the concrete compact into all corners. The concrete is then troweled to a hard finish in the usual way, with the added precaution that the entire top surface of every bar in the grating be kept exposed.



PROPERLY PREPARED SURFACE OF HARDENED CONCRETE SLAB FOR RECEIVING THE NEW FINISH

The top of the concrete slab has been roughened with pneumatic chipping tools so as to provide bond for the wearing course. Note that the entire surface has been chipped off. In order to provide for accurate grades, wood screeds have been firmly nailed to pegs set into drilled openings.

REPAIRING DEFECTIVE FLOOR FINISH

Defects that may develop in concrete floor finishes can usually be traced to the non-observance of the fundamental facts governing their installation, or to misuse of the floor by subjecting it to service for which it was not designed.

Dusting

Floor finishes that dust under service may be repaired by the employment of one of the hardener treatments as described on page 11 of this booklet. The success of such a treatment will depend upon the actual conditions of the floor as reflected in the quality of the workmanship employed during the construction. Hardener treatments may or may not stop dusting.

Cracking

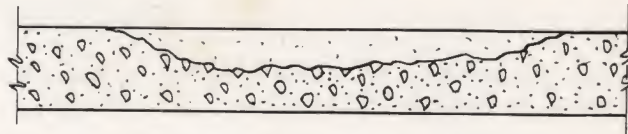
Cracks in concrete floor finishes may be classified under two headings: (1) Cracks originating in the base and extending through the finish. These are commonly known as structural cracks; (2) cracks confined to the finish layer. These may be further divided into (a) cracks extending through the full thickness of the topping, and (b) those of a superficial nature, ordinarily called hair cracks, or crazing.

Cracks of whatever origin are difficult to repair. If they develop in areas of any size, or become too evident over the whole floor surface, the more economical method of repairing is to remove the entire affected area by chipping, to the depth of at least one inch. A new wearing surface should be applied under the specifications for "One-Inch Bonded Topping" given on page 13.

Chipping off defective topping should be carefully done with pneumatic tools or by hand, and the entire area should be removed until clean, sound concrete is exposed. In no case should the depth be less than one inch. Feathered edges should be avoided and the full depth of the chipped area should be maintained up to the point where it joins with the sound topping. The accompanying figures illustrate correct and incorrect methods of patching defective floors.

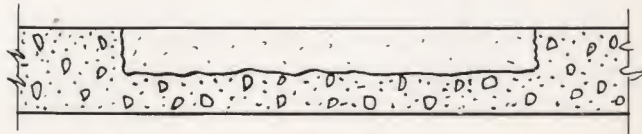
Regardless of the nature of defective floor finishes, whether soft spots, dusting or cracks, there is no method of repair as effective as careful patching by chipping away the defective areas and replacing the topping with properly designed concrete placed and finished under satisfactory specification and capable supervision.

Patches should be protected against too early use until they have been thoroughly hardened and cured.



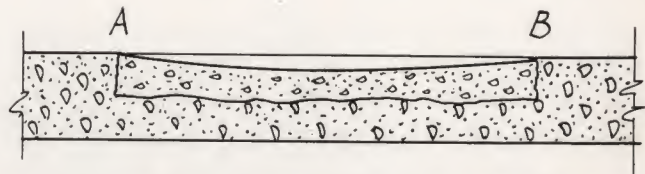
INCORRECTLY INSTALLED PATCH

Patches installed with feathered edges will soon break down under trucking.



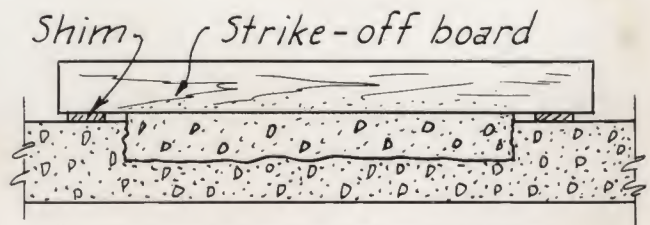
CORRECTLY INSTALLED FLOOR PATCH

The chipped-out area should be at least one inch in depth with the edges perpendicular.



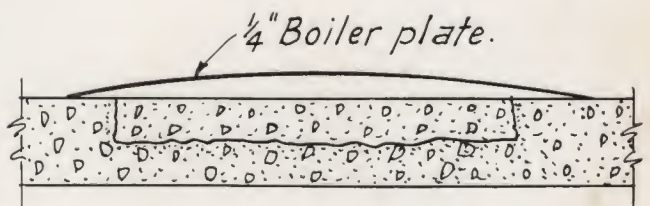
RESULTS OF INCORRECT SCREEDING OF PATCH

When a patch is originally struck off to the level of the floor, the concrete will sag in the center, due to the fact that the straight edge has a tendency to cut off slightly below its lower edge and to the fact that the concrete shrinks during hardening. Additional concrete placed in the concave area will soon chip out under traffic.



CORRECT METHOD OF SCREEDING PATCH

The strike-off board is held slightly above the level of the floor by strips or shims laid the length of the patch on two sides. For large patches the thickness of these strips will be greater than for small patches. The concrete is allowed to rest for 1 to 2 hours. This allows the concrete to attain some of its initial shrinkage before being troweled to its final plane and will result in a uniformly level surface, plane with the rest of the floor.



PROTECTION OF PATCHES

Patches should be kept continuously wet and protected from traffic for a period of 10 days. An economical method of protection consists in using a piece of 1/4-inch steel sheeting bent as shown and placed over the patch to take traffic during the curing and hardening period.

MAINTAINING AND CLEANING CONCRETE FLOOR FINISH

Well-constructed concrete floor finishes will require little maintenance other than cleaning. Periodic cleaning is essential to the durability of the floor, for accumulations of grit and dirt on floors subjected to traffic will be ground into the finish and start dusting.

Floor surfaces in bottling or canning plants, that may be subjected to spilled milk, syrups, fats and oils, and other industrial products, should be thoroughly scrubbed at least once a day. Warm, soapy water and stiff brushes should be used, after which the floor should be mopped dry. Electric scrubbing machines have frequently been found economical and efficient for cleaning floor areas.

Surfaces subjected to heavy trucking should not be allowed to accumulate a crust of dirt, as sometimes happens in molasses, sugar and oil warehouses. Trucks ride unevenly over these obstructions, which impose undue impact stresses on the floor finish, and also increase the tractive effort of the trucks.

Garage and power house floors frequently become soiled with mineral and lubricating oils. As a general rule these oils have no detrimental effect on properly made concrete, but their presence on the floor gives bad appearance and makes the surface slippery and dangerous. Such floors may be cleaned by first scraping off all thickened oil crusts, and then mopping the floor with gasoline-soaked waste. After as much of the oil and grease as possible is removed, the floor should be thoroughly scrubbed with warm soapy water and mopped dry. This treatment will not remove stains, but will remove objectionable coating of oil and grease. Due precautions against fire should be taken during the mopping with gasoline.

Decorative floors should be cleaned with warm soapy water, prior to original use, and two or three times a week during service. Only soft water and mild soaps should be used on terrazzo and other types of decorative floor.



PROPER MAINTENANCE INSURES LONG LASTING FLOOR

Periodical cleaning with soap and water and power scrubbers keeps the concrete trucking surface in first-class condition. This floor in the Woodward & Tiernan Printing Company plant, St. Louis, is subject to hard use and heavy imposed loads.

APPENDIX

Attaching Equipment to Concrete Floors

Theatre seats, machinery or similar equipment may be rigidly fastened to concrete floors by the employment of expansion bolts.

In order that satisfactory results may be achieved it is necessary that particular attention be directed to the concrete floor. The mixture should be designed for strength to resist the stresses developed by the equipment to be attached. A well-proportioned mix should be used, with no more than $4\frac{1}{2}$ to 5 gallons of mixing water for each sack of cement. The floor should be placed, finished and cured under the specifications for Light Duty Floors as outlined on page 14, except that the thickness of the wearing course should be increased to not less than 2 inches.

After the floor has hardened and cured, the location of the bolts may be marked out and the holes carefully drilled to the proper depth for the insertion of the expansion shell.

Linoleum, Rubber and Cork Tile

It is sometimes desired to cover concrete floors with a resilient, soft material such as linoleum, rubber or cork.

When coverings of this nature are to be employed, it is necessary that the concrete floor have a smooth even surface, finished slightly below grade, according to the thickness of the floor covering.

The concrete must be thoroughly dry before the surfacing materials are cemented in place. Moisture even in very small quantities will eventually lead to the decomposition of the adhesive. A simple test to determine whether or not the concrete is dry may be made by laying pieces of linoleum at several places on the floor slab and weighting them down uniformly in contact with the surface. After 24 hours, if moisture appears between the concrete and the linoleum, it will be necessary to let the concrete further dry out before the covering may safely be applied.

Carpet

Floors to be covered with carpet require wood nailing strips, usually around the border of the area. These should be well-seasoned timber, dressed to 1 by 2

inches and embedded in the unhardened concrete. In lieu of the nailing strips, special snap inserts may be embedded in the concrete. The necessary auxiliary attachments are fastened to the underside of the carpet at the proper places.

The surface of the concrete floor should be screeded and troweled flush with the tops of the wood strips and should present a smooth and even surface. Carpet pads or cushions may be placed on the thoroughly dry concrete before the carpet is laid. This will prolong the life of the carpet and assist in producing sound-proofness.

Acid-proof Mastic Finishes

Floors in chemical laboratories, acid plants, dye houses, storage battery buildings and similar structures in which strong acid solutions are manufactured or handled may require the protection of an acid-proof covering. The use of specially manufactured asphalt blocks has proved satisfactory for this purpose. These blocks should consist of inert crushed rock aggregate bound together with an acid-proof asphalt and molded under high pressure to the desired dimensions.

The concrete base slab is placed and finished about $1\frac{1}{2}$ inches below grade, according to the thickness of the blocks. The surface should be troweled to a smooth surface, and accurately pitched to drainage fixtures which should be made of acid-proof material.

After the base has hardened and cured, the blocks are laid without the use of a binding material, as close together as possible. The surface is then pointed with hot acid-proof asphalt and a uniform layer of clean fine sand is dusted on. The blocks soon weld under traffic to a continuous surface.

Where traffic is unusually heavy, the asphaltic sealing coat may be omitted. If premolded blocks are not available, the mixture of asphalt and crushed rock may be installed as a continuous sheet from 1 to $1\frac{1}{2}$ inches thick.

Asphaltic coverings if properly installed should give satisfactory service in the presence of acids. They should not, however, be subjected to the action of hot water, fats, greases or other heated solutions.

Design and Control of Concrete Mixtures

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Now- Predetermined Qualities

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This booklet, "Design and Control of Concrete Mixtures," emphasizes the importance of water-cement ratio on the qualities of concrete—such as strength, watertightness, and durability. Selection of materials, estimation of quantities, importance of curing, and control of concrete in the field are discussed. For a free copy of this practical aid, address the nearest District Office.

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